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Methods for Characterization of Mass Transfer Boundary Layer in an Industrial Semiconductor Wafer Plating Cell

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The knowledge of limiting current density and thickness of diffusion boundary layer is particularly important in obtaining good quality deposits of plating and especially of high speed plating. However, there have been very limited methods available to characterize the mass transfer boundary layer in an industrial semiconductor wafer plating cell due to complicated cell geometry and limited accesses. It lays a burrier at transferring experimental results obtained from bench or beaker scale testing to the real industrial plating tool. This experimental study describes a method to characterize mass transfer boundary layer in an industrial plating cell.

Experiments were performed on a Nexx Stratus plating cell, which is equipped with paddle arms to promote mass transfer and is specially designed for MEMS, flip chip bumping, and WL-CSP applications. Cathode limiting current densities were obtained by linear Voltammetry with a programmed power supply in a dilute electrolyte solution. The mass transfer boundary layer thickness was calculated based on the results of the limiting current density.

As shown in the figure1, the speed of paddle arms had a significant impact on the thickness of boundary layer near the wafer. A virtually 6 times thinner of boundary layer was able to achieve with paddle arms than without the paddle arms. A thickness of boundary layer below 10μm is able to obtained by the paddle arms at high speed (>800 rpm). At a paddle speed of 600 rpm, a deposition rate of 2~6μm/min was achievable on through-mask copper deposition with a commercial available copper bath (see figure 2). At a low paddle speed of 60 rpm, dendritic growth was observed even at a deposition rate of 1.8μm/min.

With known concentration of ions in the solution and limiting current, the relationship between the speed of paddle arm and RPM of rotating disk electrode can be established (see figure 3). An 800-rpm of paddle arm would be equal to1, 800 rpm of rotating disk electrode with the same thickness of boundary layer.

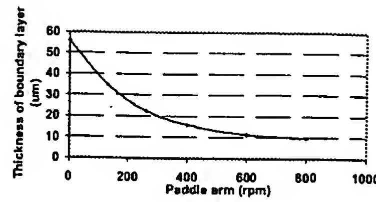
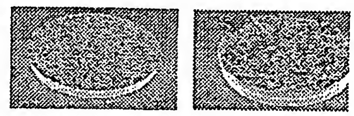


Figure 1. Effect of speed of paddle arm on the thickness of boundary layer on the cathode surface.



600 rpm, 5μm/min   60 rpm, 1.8μm/min

Figure 2. Effect of paddle speed on the surface morphology.

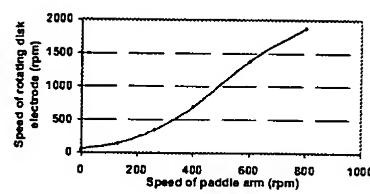


Figure 3. Speed of paddle arms corresponding to speed of rotating disk electrode with equal thickness of boundary layer.

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